

FUEL SYSTEM

[0001] The present invention relates to a fuel system for an internal combustion engine and, in particular, to a fuel system including an accumulator volume in the form of a common rail for supplying fuel to a plurality of injectors.

[0002] In conventional common rail fuel injection systems, it is common to provide a single pump for charging an accumulator volume, or common rail, with high pressure fuel for supply to a plurality of injectors of the fuel system. The timing of injection is controlled by means of a nozzle control valve associated with each injector. One advantage of the common rail system is that the timing of injection of fuel at high pressure is not dependent upon a cam drive mechanism, and so fast and accurate control of the timing of injection can be achieved with the nozzle control valves. However, achieving very high injection pressure within a common rail system is problematic and the high levels to which fuel must be pressurised can cause high stresses within the pump and within the rail. The rail must therefore be provided with a relatively thick wall for pressure containment, making it heavy and bulky. Parasitic fuel losses can also be high.

[0003] It has been recognised that significant improvements in combustion quality and efficiency may be achieved by rapidly varying the injection pressure level and injection rate within an injection event. Such variations in the injection characteristics can be difficult to achieve rapidly with common rail systems, and the efficiency of the system can be limited. For example, in a common rail system designed to achieve injection at a high rail pressure, it is also possible to achieve a lower injection pressure by relieving some of the high pressure fuel to a low pressure reservoir. This, however, is an inefficient use of pumping energy.

[0004] By way of background to the present invention it is acknowledged that Electronic Unit Pumps (EUPs) provide a different fuel system concept to that of the common rail system. In an EUP fuel system, one EUP is provided for each cylinder of the engine and has a dedicated injector to which pressurised fuel is supplied by the EUP for injection purposes. The EUP includes a dedicated pump having a cam-driven plunger for raising fuel pressure within a pump chamber, from where pressurised fuel is supplied to the associated injector. In an EUP system, however, the constraints of the cam drive mechanism can limit the range of injection timing that can be achieved. It is also acknowledged that Electronic Injectors (EUIs) are known, in which the associated injector is incorporated within the same unit as its dedicated plunger and injection is controlled by means of a nozzle control valve of the unit.

[0005] It is one aim of the present invention to provide a common rail fuel system which provides improvements over known common rail fuel systems and which addresses, in particular, the issue of variable injection characteristics and of parasitic fuel losses so as to provide enhanced system efficiency.

[0006] According to a first aspect of the present invention there is provided a fuel system for supplying fuel to a plurality of injectors, the fuel system comprising:

[0007] an accumulator assembly having first and second accumulator volumes defined within a common accumulator housing,

[0008] supply means for supplying fuel at a supply pressure level to the first accumulator volume,

[0009] a plurality of unit pumps, each for receiving fuel at the supply pressure level from the first accumulator volume and for pressurising said fuel to an injectable pressure level for supply to the second accumulator volume,

[0010] each unit pump including a pumping plunger for pressuring fuel within an associated pump chamber, wherein the unit pump is integrated with the accumulator housing so as to permit communication between the first accumulator volume and the pump chamber internally within the accumulator housing.

[0011] Preferably, each unit pump is integrated with the accumulator housing by mounting within an opening or cross bore provided in the accumulator housing, so that the unit pumps pass through the accumulator housing.

[0012] The accumulator assembly is preferably a rail assembly comprising a first rail volume (the first accumulator volume) and a second rail volume (the second accumulator volume) housed within a rail housing (the accumulator housing).

[0013] It is a particular benefit of the fuel system of the present invention that a first rail volume for lower pressure fuel may be arranged adjacent to, side by side or in parallel with a second rail volume for higher pressure fuel, within a common rail housing, and thus a cooling effect is provided for high pressure fuel within the second rail volume.

[0014] In a further preferred embodiment the assembled unit pump and rail assembly, forming an integrated pump/rail assembly, is configured such that each unit pump is received within the accumulator housing so as to permit communication between the second accumulator volume and its pump chamber internally within the pump/rail assembly, with the communication path conveniently traversing an interface between unit pump and rail housings.

[0015] Preferably, a plurality of unit pumps are provided, equal in number to the number of injectors to which fuel is to be supplied.

[0016] The first rail volume may be communicable with the pump chamber of each unit pump within the actuator housing via first valve means, typically in the form of a non-return valve. The first valve means has an open position, in which the pump chamber communicates with the first rail volume, and a closed position in which said communication is broken.

[0017] It is a particular benefit of being able to inject fuel at two pressure levels, that a sequence of a main injection of fuel having a second (higher) pressure level followed by a post injection of fuel having a first (moderate) pressure level can be achieved and this can have benefits for after-treatment purposes. It is also desirable to inject a pilot injection of fuel at a first pressure level followed by a main injection of fuel at a second pressure level, or to provide a boot-shaped injection characteristic, which also provides benefits in terms of engine noise and emissions levels.

[0018] The fuel system therefore preferably includes second valve means, wherein the second rail volume is communicable with the pump chamber of each unit pump through the second valve means.